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Young radio-loud AGN: A new sample at low redshift

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We report on the investigation of a complete sample of young radio-loud AGN at $z \leqslant 0.25$, selected using the new comprehensive radio surveys and the optical APM/POSS-I catalog. This new sample will provide a unique opportunity for statistical studies of the early evolution of radio-loud AGN, free of cosmological evolution effects. In particular, their local luminosity function, linear-size and dynamical age distributions, may strongly constrain possible evolution scenarios. In addition, this new sample is well suited for statistical studies of other important properties, like their X-ray and infrared emissions, optical cluster environments, and neutral hydrogen in absorption towards the compact radio sources.

1. Young radio-loud AGN

Cumulative evidence suggests that Gigahertz Peaked Spectrum (GPS) sources, Compact Symmetric Objects (CSO) and Compact Steep Spectrum (CSS) sources are young. Multi-epoch VLBI observations indicate that CSO and GPS sources have dynamical ages of typically $10^2 - 10^3$ year (Owsianik & Conway 1998; Owsianik, Conway & Polatidis 1998; Tschager et al. 2000), while radio-spectral analyses indicate that the somewhat larger CSS sources are up to 10^4 years old (Murgia et al. 1999). It is therefore thought that these young AGN are the progenitors of large, extended radio sources. If so, the relatively large number of young objects suggests they substantially decrease in radio-luminosity with time (Fanti et al. 1995; Readhead et al. 1996; O'Dea & Baum 1997).

Compared with old and extended objects, young radio sources are only rarely found at low redshifts, e.g. only 3 GPS galaxies are found at $z < 0.1$ in the combined samples of Stanghellini et al. (1998) and Snellen et al. (1998). Since classes of radio sources, representing similar objects at different ages, are expected to have similar birth functions, any difference in their redshift distributions should be the result of a difference in their luminosity distributions. Snellen et al. (2000) suggest that the redshift bias may be caused by a qualitatively different luminosity evolution for a radio source in the early stage of its life-cycle, producing a flatter collective luminosity function for young objects. This implies that simple statistical analysis of source samples conducted over a large range in cosmological epoch are unreliable and should be performed over a much smaller redshift range.

2. A new sample at low redshift

A complete sample of young radio-loud AGN at low redshift is an ideal tool to study the evolution of radio sources in more detail. Their relative proximity means that it is

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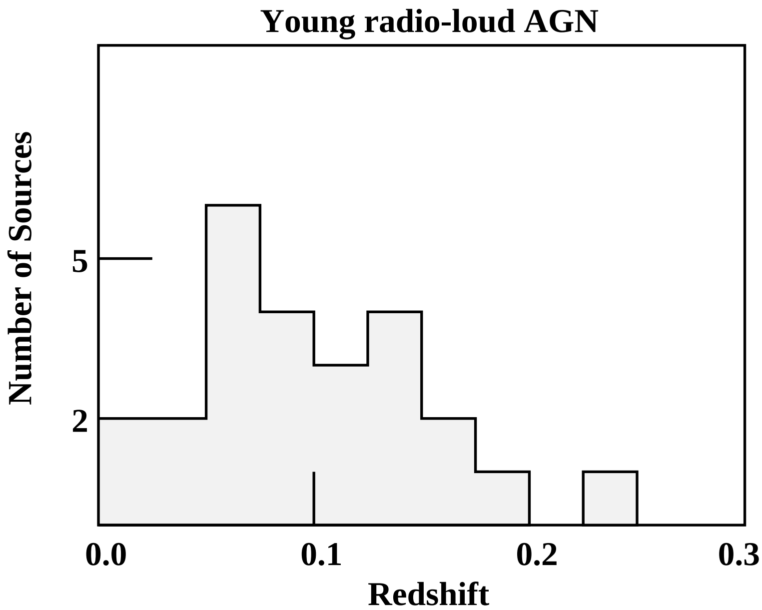

FIGURE 1. The redshift distribution for the sources in our sample ($\sim$ 80% complete).

much easier to obtain key observations, like spectroscopic redshifts. Furthermore, the statistical properties of other types of radio sources to which the young radio sources are to be compared, are well determined in the local universe. Only since the completion of the new comprehensive radio surveys it is possible to construct a reasonably sized sample. Although the objects in such a sample typically have lower luminosities than their well-known counterparts at higher redshifts, they inhabit an interesting luminosity range of $P_{5\mathrm{GHz}} \sim 10^{24-26}$ W/Hz, at and below a possible turnover in their luminosity function (Snellen et al. 2000)

The combination of WENSS at 325 MHz (Rengelink et al. 1997), FIRST (White et al. 1997) and NVSS at 1.4 GHz (Condon et al. 1998), GB6 at 5 GHz (Gregory et al. 1996), and the Automated Plate Measuring machine (APM) catalogue of the POSS-I (McMahon & Irwin 1991) forms the basis of our candidate sample of young radio sources. Firstly, all point sources ($\theta < 2''$) were selected from the FIRST survey with $S_{1.4\mathrm{GHz}} > 100$ mJy and correlated with the optical APM/POSS-I catalog in the area overlapping with the WENSS survey region (1666 objects). Only 44 of those coincide with an extended optical object in the APM/POSS-I catalog with a red magnitude $e < 16\overset{\mathrm{m}}{.}5$. Although this sample is complete for sources which are optically thin at the selection frequency, it may miss sources which peak at frequencies > 1.4 GHz due to their compact radio morphologies. We therefore complemented the sample with sources from the flat spectrum CLASS survey with an 8.4 – 5 GHz spectral index such that their 1.4 GHz flux density would have been brighter than 100 mJy, if they were not synchrotron self-absorbed. This yielded an additional 11 sources which are optically identified with bright extended objects, and makes the sample complete for sources with peak frequencies < 5 GHz.

After the initial automated selection, maps from FIRST, NVSS, WENSS and the Digitized Sky Survey (DSS; Lasker et al. 1990) centred on the positions of the 55 objects were checked to see whether the compact radio sources were not part of larger structures, and whether the optical identification was genuine. Note that we avoided any further selection on the radio spectrum, which will hopefully enable us to get a better view on

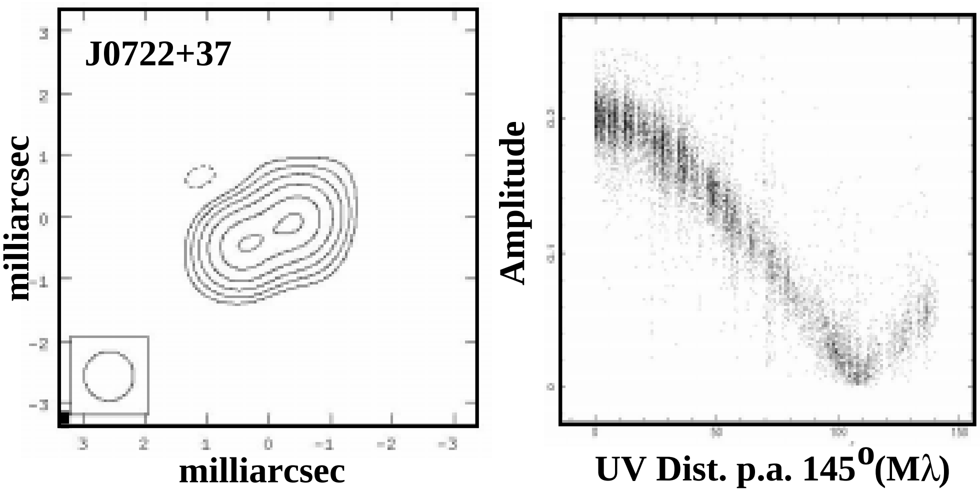

FIGURE 2. Global VLBI data at 5 GHz for a very compact source in our sample. The left plot shows the amplitude of the visibility data as function of UV distance along a position angle of 145°. If the source grows, the UV-minimum (currently at $\sim 110M\lambda$) will move inwards, which may be detectable within a few years.

the questions whether all young radio-loud AGN are GPS sources and/or CSOs and/or vice versa. The remaining sample consists of 37 objects.

3. Status and future plans

We observed the sample with the VLA at 5.0, 8.4 and 15 GHz, and with Effelsberg at 2.7 and 10.5 GHz (additional observations are planned at 32 GHz) to obtain accurate radio spectra. Preliminary analysis indicates that indeed all sources are GPS or CSS sources and therefore most likely young radio sources unaffected by Doppler boosting. Eight objects have spectroscopic redshifts in the literature. Additional spectroscopic observations with the Calar Alto 2.2m telescope yielded another 17 redshifts of nearby galaxies. About 15 % of the optical identifications turned out not to be nearby objects. The redshift-distribution of the genuine nearby young radio sources is shown in Fig. 1 ($\sim$ 80% complete).

For observational strategic purposes, the sources in the sample were divided into 3 sub-samples according to their overall radio spectra: 1) The small size sub-sample, containing sources which exhibit a turnover at frequencies $>$ 1.4 GHz, has been observed with the EVN+VLBA global VLBI array at 5 GHz. 2) The intermediate size sub-sample, containing sources which show a spectral turnover at frequencies $<$ 1.4 GHz, has been observed with the EVN only at 1.6 GHz, while observations are planned with MERLIN at 1.6 GHz for the 'large' size sub-sample, which contains sources showing no sign of a spectral turnover in their overall radio spectrum.

Preliminary reduction of the global VLBI observations of a few small size sources indicate that their morphologies are consistent with them being compact doubles, as expected for these objects. Especially for those sources for which the flux density ratio of the two components is near unity, multi-epoch VLBI observations will likely enable the determination of their dynamical ages (e.g. Fig. 2). We believe that the dependence of age on radio luminosity and angular size, in combination with their overall luminosity function and source size distribution, will put strong constraints on possible evolution scenarios.

In addition to the interesting prospect of using this new sample for source evolution studies, it opens up other possibilities as well. It provides a unique opportunity to study their X-ray and infrared emissions, of which very little is known at this moment (eg. O'Dea 1998; Fanti et al. 2000; O'Dea et al. 2000). In particular we look forward to studying the neutral hydrogen gas in the centres of these galaxies in absorption towards the compact radio sources, which has already let to some very interesting results in individual cases for this type of object (eg. Conway 1995, Peck, Taylor & Conway 1999, Pihlström et al. 1999, Conway & Schilizzi, these proceedings). This will now be possible for a complete sample of objects at an unprecedented sub-parsec scale resolution.

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